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A.E.R.E. HP/R 737
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THE HAZARD FROM INHALED FISSION PRODUCTS IN RESCUE OPERATIONS AFTER AN ATOMIC BOMB EXPLOSION

A JOINT A.E.R.E. AND HOME OFFICE REPORT.

BY

A.C. CHAMBERLAIN (A.E.R.E.)
G.R. STANBURY (HOME OFFICE)

with Medical Assessment by

G/CAPT. D.A. WILSON (R.A.F.M.S.)
MAJ. A.R.T. LUNDIE, M.C. (R.A.M.C.)

and with the collaboration of

J. RUNDO (A.E.R.E.)
R.D. WIFFEN (A.E.R.E.)
J.W. COWGILL (C.D.E.E. PORTON)
G. DAVIES (C.D.E.E. PORTON)
A.J. BATCHELOR (HOME OFFICE)
P.B.V. HEARD (HOME OFFICE)

MINISTRY OF SUPPLY
HARWELL, BERKS.
1951

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THE HAZARD FROM INHALED FISSION PRODUCTS IN RESCUE OPERATIONS AFTER AN ATOMIC BOMB EXPLOSION

A report of trials carried out jointly by Home Office and Atomic Energy Research Establishment (Harwell) on 1st and 8th May, 1951.

By A. C. Chamberlain (A.E.R.E.) and G. R. Stanbury (Home Office) with Medical Assessment by G/Capt. D. A. Wilson (R.A.F.M.S.) and Major A. R. T. Lundie, M.C. (R.A.M.C.) and with the collaboration of

J. Rundo R. D. Wiffen	A.E.R.E. Harwell
J. W. Cowgill G. Davies	C.D.E.E. Porton
A. J. Batchelor P. B. V. Heard	Home Office

Abstract

(en)

Brick and plaster dust made radioactive with iodine-131 has been used as a tracer to investigate the relative hazards of airborne activity and external gamma radiation during typical Civil Defence operations in contaminated debris. It is concluded that, during the 24 hours following the burst, external radiation will be the dominant hazard. (auth)

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Letter from G. I. Ashworth,
by authority of British Embassy dated 4-18-58
by C. P. Boggess **TIE, date** 9-25-58

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CONTENTS

THE HAZARD FROM INHALED FISSION PRODUCTS IN RESCUE OPERATIONS AFTER AN ATOMIC BOMB EXPLOSION

Part 1. Object of trials

1.1 Rescue Work - the need for rapid action

The immediate task of the Civil Defence Corps after an atomic explosion is to rescue as many people as possible from the debris. Last war experience showed, however, that unless this rescue work is carried out during the first day, and in most cases in the first eight hours, there is only a small chance of rescuing people alive. It is important to ensure, therefore, that, as far as possible, nothing is allowed to impede the rapid deployment of the Corps and its high pressure attack on the rescue problem.

In most literature on the effects of atomic weapons the impression is created that the inhalation or ingestion into the body of even the minutest amount of radioactive material is extremely dangerous, and on this account the necessity of wearing respirators in areas contaminated with fission products has been tacitly assumed. However, it is known from experience that people wearing respirators are only able to work for a comparatively short time at high pressure, so that unless it is absolutely necessary, this restriction of activity must be avoided. It is pertinent to enquire, therefore, whether in actual practice the amount of radioactive material breathed in can ever be a serious hazard.

1.2 Methods of controlling hazards

There are, of course, always two hazards associated with work in an area where fission products have been deposited,

(a) that from the whole body gamma and local beta radiation emitted by the fission products; and

(b) that from the actual absorption of fission products into the body.

The first risk will be controlled in war by working to a maximum permissible dose which is not likely to produce invalidty. It is expected that this dose will be 25r. Each rescue party will be issued with one or more personal dosimeters so that the dose which each man accumulates can be measured and subsequently recorded. Thus the control of the external gamma ray hazard is fairly simple and straightforward.

The problem then is, how does the external hazard compare in magnitude with the internal hazard, and will control of the first automatically provide control for the second?

Theoretical considerations indicate that under normal working conditions the internal risk is small compared with the external gamma risk. In the United States book on "The Effects of Atomic Weapons" it is stated (11.81) for example that

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"if in a given area the dosage due to external radiation is down to a safe level, there will, in general, be little, if any, danger of enough radioactive material being fixed in the system for it to constitute an internal hazard".

The calculations on which such conclusions are based, do, however, involve many rather speculative assumptions because of the lack of accurate data. For example, it is necessary to know, amongst other things

(a) the degree of ground contamination associated with a given gamma ray dose

(b) the proportion of active dust stirred up into the air and held in suspension during any given operation

(c) the net amount of dust retained in the lungs

(d) the proportion of dust filtered out by the nose

(e) the different degrees of absorption of different fission products in the body fluids

(f) the proportion of the fission products which consist of the dangerous long-lived isotopes which may be deposited in the skeleton.

No information on (b) was available, and to get some figures it was decided to carry out some trials in conditions as closely related as possible to actual rescue work.

1.3 Organisation of the trials

The main difficulty of such a trial is that of simulating the deposition of radioactive fission products. For a low air burst bomb where ground contamination may be heavy it can be assumed that a high proportion of the activity becomes attached to grit and dust which is produced by the collapse and disintegration of buildings at and around ground zero. If this is so then the conditions can be simulated by selecting some suitable building material such as brick and plaster dust, making it radioactive, and then spreading it as uniformly as possible so that it can be stirred up into the air along with the ordinary inactive dust. If the composition of the active material is in fact heavier than brick dust, then the inhalation risk is correspondingly reduced since the heavier particles are not so easily airborne. The chance of coming across dust much finer than brick and plaster dust in practice was considered to be slight, but this limitation of the method must be recognized.

It was decided therefore to use brick and plaster dust from a bombed site, made radioactive artificially, for simulating the fission product deposition and to carry out some standard rescue operations during which dust would be stirred up into the air and inhaled.

Simultaneous measurements of the gamma ray dose from the activated dust on the ground and of the airborne concentration of the dust would enable an estimate to be made of the relative hazards from these causes.

/After

After consultation between H.O. and A.E.R.E., it was agreed to carry out the trials on the rescue range at the Civil Defence School, Eastwood Park, Falfield, Gloucester,* a plan of which is shown in Fig. 1.

The sets which were chosen were

(a) one of the cubicles in Set No. 3 which is used for practising rescue work in confined spaces. The rescue worker works his way into the rear of the compartment in a search for casualties, passing back some of the debris by hand and shovelling the rest so as to clear a way for the eventual withdrawal of the casualty. A photograph of this cubicle is included (Plate 1) and details of its construction are given in Fig. 2.

and (b) the collapsed house of Set No. 18A which is used for training in debris clearance in the open by hand during a systematic search for trapped casualties. Two photographs of this set are included (Plates 2 and 3), and details are given in Fig. 3.

The first operation produces about the highest concentration of dust in the air of any of the regular rescue operations since the working space is so confined. The second is typical of most of the operations carried out during the last war, and the dust concentration is usually rather lower.

The trial in the first set was carried out on 1st May 1951 and in the second set on 8th May 1951.

A number of the Falfield rescue staff volunteered to take part in the trials, and though it was not expected that they would be exposed to any serious risk, arrangements were made to give them complete protection. C.D.E.E. provided some of the latest experimental models of protective clothing - described in details in Appendix- and steel helmets, hoods and respirators were worn as well as gum boots and strong rubber gloves. A doctor was present throughout the tests and close observation was kept on those engaged in the work. No harmful effects whatever were experienced, and the external gamma ray dose rate was never more than twice the allowable dose rate for an 8-hour exposure, although the tests only lasted for an hour on each of the two occasions.

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* By kind permission of the Commandant, Brigadier A. M. Toye, V.C., M.C.

Part 2 Physical Methods and Measurements

2.1 Preparation of activated dust

The first method tried for producing activated dust was by direct irradiation in B.E.P.O. of a sample of brick and plaster dust supplied by Falfield, and originating from a bombed site in Bristol.

The results were quite satisfactory at first sight. An activity of about 180 microcuries/gm. of dust was obtained after 72 hours irradiation, followed by 6 hours cooling. This activity was mainly sodium 24, which has a 14.8 hours half-life. After three days, when the sodium 24 had decayed to 4% of its original activity, two more isotopes could be detected. One was 14-day phosphorus 32, and the other 152-day calcium 45.

There are, however, two objections to the use of irradiated dust.

(a) While the sodium 24 activity is relatively harmless and would rapidly vanish, the long-lived calcium 45 activity might create a hazard for many months.

(b) Any method involving direct irradiation of dust particles gives an activity per particle proportional to the mass of the particle, but adsorption of fission product activity by dust particles is probably proportional to the surface area. By using a dust with activity proportional to the mass, the heavier particles receive more than their share of activity, and hence the ratio of airborne to deposited activity is upset.

Second method - Adsorption of Iodine 131 onto dust

Previous experience had shown that carrier-free isotopes, and in particular 8-day iodine 131, are very readily adsorbed onto surfaces, and are firmly held there. It was found that if samples of dust were put in dishes containing a solution of carrier-free iodine 131 in carbon tetrachloride, and the carbon tetrachloride allowed to evaporate off, nearly all the iodine 131 remained adsorbed onto the dust. Moreover it was not removed by blowing air over the dust, despite the comparatively high vapour pressure of elemental iodine.

Whilst the initial decay of the iodine 131 activated dust is much slower than that of the irradiated dust, from about one week onwards it is more rapid, and from six weeks onwards the percentage residual activity is less.

The adsorption method was therefore used for preparing the activated dust. In the first experiment 16 mc. of iodine 131 was adsorbed onto 16gm. of dust. In the second experiment 200 mc. of iodine 131 was adsorbed onto 50 gm. of dust, which was mixed with a very much larger quantity of inactive dust before dissemination so as to facilitate an even distribution over the site.

/2.2 Methods

2.2. Methods of measuring external gamma dose rate and airborne dust

External radiation

In both experiments the gamma radiation from the iodine 131 activated dust was measured with a beta-gamma radiation meter type 1118 (similar to the monitor type 1043C, but with a much larger chamber - having a full scale reading on the sensitive range of 15 mr/hr.). Also available was a Civil Defence type contamination meter, which was useful in measuring the radiation on the outskirts of the building as it is sensitive down to 0.1 mr/hr.

In the first experiment the dose rates were also measured with a gamma radiation meter type 1005B and they agreed to within 10% with those from the 1118.

Concentrations of active dust in the air

Measured quantities of air were drawn through Whatman No. 4 filter papers held in bakelite filter holders. The filter holders, of Porton design, have a nozzle 1 cm. in diameter, and widen out so that the air is drawn through a filter paper of 4 cm. diameter.

The air was drawn through at either 10 or 30 litres/min. These rates are within the limits of the normal human breathing rate.

Particle size distributions

Particle size distributions were obtained by the use of a thermal precipitator. In this method 7 cc. of air per minute are drawn through a slit between two microscope slides which contains a hot wire. The dust-free space round the hot wire causes all the dust particles to be deposited on the slides, where they are afterwards counted under the microscope.

2.3 Results

Trial on 1st May 1951

16 gm. of dust with 16 mc. of iodine 131 adsorbed on it was sprinkled in the cubicle of Set No. 3 (see Plate 1 and Fig. 2), including about 4 mc. which was put on the "loose roof".

The gamma ray dose rate, measured before operations began, varied from 3 to 8 mr/hr. in different parts of the compartment, with an average of 5 mr/hr. Not much change was noticeable when shovelling operations began.

The operations lasted 30 minutes, divided into four 5 minutes working periods with periods of rest between, during which the filter papers in the dust measuring apparatus were changed. The mean active dust concentrationsduring these periods are given in Table 1.

/Table 1

Table 1.

Measurements of airborne activity in the trial on 1st May in the cubicle of Set No. 3

Period	Nature of Work	Activity concentration in $\mu c/m^3$ at height: 5ft.	3ft.	1ft.
1 11.25 - 11.30	Shovelling debris out of recess into corridor	0.61		0.56
2 11.37 - 11.42	Cutting hole in wall of recess	0.023		(failed)
3 11.50 - 11.55	ditto	0.019		0.005
4 12.00 - 12.05	Shovelling debris back into compartment	0.71		1.03
Average of all working periods		0.34	0.30*	0.40

The sampling rate was 10 litres/min., except for the 3 ft. measurement, which was run at 30 litres/min. through all the working period. The dust concentration by weight at this point was about 110 mg/m^3 of dust (active + inactive).

Trial on 8th May 1951

The collapsed house of Set No. 18A (see Plate 2 and Fig. 3) has walls standing about 3 ft. high, with a mass of bricks and debris filling the inside of the house. At the time of the trial there was a strong N.E. wind blowing with an occasional spatter of rain. The working area had been protected before the trial and a good deal of dust was raised, more than normal in actual operations of this kind in the opinion of an experienced observer (Colonel Batchelor).

200 mc. of iodine 131 on 50 gm. dust was used, and it was first mixed with about 10 kg. of inactive dust, of rather different and finer composition in order to facilitate more uniform distribution over the site of operations. This was then spread over the working area, about 5 m. x 3 m. in the front centre of the building. The gamma dose rate ranged from 7.5 to 25 mr/hr. in the working area, both before and during the work and the average value was about 15 mr/hr. The dose rate above the pile of cleaned rubble outside the house after the work was finished was 4 mr/hr. The dose rate behind the building (as measured with the Civil Defence contamination meter) was only 0.1 to 0.2 mr/hr., as the walls and rubble provided good shielding against the relatively soft gammas from iodine 131 which have maximum energy about 0.4 Mev.

Three sets of air sampling apparatus (10 litres/min.) were arranged in an arc behind (and downwind) of the working area, No. 1 to the right, No. 2 in the centre, and No. 3 to the left, looking from in front of the house. No. 4, a 30 litres/min. apparatus,

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was placed with the filter holder fixed to the window frame just in front (and rather upwind) of the working area. Nos. 1, 2 and 3 were at a height of about 4 ft. and No. 4 at 6 ft. above ground level.

Owing to the difficulty of changing filter papers in the open with a strong wind blowing, all the samples were run unchanged through the 40 min. of the working period. The results were as follows:

Table 2

Measurements of airborne activity in the trial on 8th May in Set No. 18A

Nature of Work	Activity concentration in μc/m^3 at position No. 1	No. 2	No. 3	No. 4
Hand clearing debris from ruined house in search for buried casualties	0.033	0.026	0.024	0.011

The active dust level in this trial was about one-tenth of that in the first trial, though the external dose rate was three times as great.

Since the average ground concentration was 13 mc/m^2, and the average air concentration 0.024 μc/m^3, it follows that a proportion 2×10^{-6} of the activated dust was airborne per m^3 of air.

Particle size distribution

Particle size distributions of the dust are given in Fig. 4. Curve I shows the distribution of the tracer dust as supplied. Curve II shows the distribution found in the air at the first trial and Curve III at the second trial. Both measurements were taken at approximately three feet.

It will be seen that the dust as supplied by Falfield gives the common straight line distribution on logarithmic probability paper, the median particle size being 0.8 μ.

The dust sample obtained in the first trial in the closed cubicle gives at the lower end a straight line distribution of similar slope with median 0.9 μ but there is a deficiency of particles from 3 μ upwards. This is reasonable as the appreciable terminal velocity of the larger particles would tend to remove them from suspension in air.

The dust sample obtained in the second (open air) trial shows quite a different distribution, the median particle size being 0.25 μ. The dust examined, of course, includes all dust, active and inactive, and in the open air with a high wind a good deal of extraneous dust would be present. Also the inactive dust spread over the site was probably finer than that used for activation.

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Part 3 Discussion of Results

3.1 Factors to be considered in the application of the experimental results to practical conditions

In applying the results of the trials carried out with iodine 131 to fission products from an atomic bomb, the following points must be considered.

(a) In the trials only limited areas were contaminated; about 2 sq. metres in the first, and about 15 sq. metres in the second. If larger areas had been contaminated to the same level the external gamma ray dose rate would have been three or four times higher in the first case and two or three times higher in the second, but the concentration of active dust would not have increased in the same proportion.

(b) The gamma ray energy of iodine 131, 0.4 Mev, is only about half that of average fresh mixed fission products, so that for the latter the gamma ray dose rate would be about twice as great as that measured in these trials.

(c) The dust used in the trials had a high proportion of small dust particles, 55% being less than 1 μ. The activity from a bomb would in many cases consist mainly of much larger particles, not so readily airborne.

(d) In practice some of the dust would be intercepted in the nose, and most likely removed after a short time by blowing or sneezing.

Since all the above factors tend to maximise the inhalation hazard relative to the external radiation hazard in the trials as carried out, it follows that if we can show that even under these conditions the external radiation hazard is dominant, then the same will be true to a much greater extent in any foreseeable conditions arising in a real attack.

3.2 Comparison of external radiation and inhalation hazards

Trial on 1st May 1951

5 mr/hr of external gamma radiation corresponded to an average of 0.3 $\mu c/m^3$ activity in the air

Hence, multiplying both sides by 5,000, we have 25 r/hr. of external gamma radiation corresponding to 1.5 mc/m^3 activity in the air.

Working for one hour in these circumstances would give an emergency permissible dose of 25 r external radiation. For the internal hazard let us assume a breathing rate of something over 1 m^3/hr; then if no respirator were worn, about 2 mc. of activity would be inhaled, of which about half might be retained, at least temporarily, in the lungs and bronchial passages.

If exposure took place 12 hours after the burst, the beta dose to the lungs and bronchial passages from 1 mc. of mixed fission products would be of the order of 10-20r. in the first 24 hours, and would be down by a factor of $2\frac{1}{2}$ due to radioactive decay alone,

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in the second 24 hours. It is important to note that this exposure is to the lungs and not to the whole body, but also that it is additional to the external gamma radiation. The integral dose to the lungs from the dust would be about 2 x 10^4 gram-roentgens, whereas 25 r, of external gamma radiation corresponds to about 10^6 gram-roentgens, or 50 times as much, so that from that aspect the extra dose would be negligible.

The possibility that restricted areas of the nose, bronchus or upper lung might receive considerably higher total doses cannot be ruled out, but as the removal of matter from these areas is normally fairly rapid it is unlikely that an erythema dose could be reached.

The special hazard of the few dangerous long-lived isotopes which are fairly readily dissolved in body fluids must be considered. The following amounts of these isotopes would be found in the 1 mc. retained, assuming that exposure took place 12 hours after burst.

Table 3

Long-lived and readily absorbed isotopes in 1 mc. of 12 hours old mixed fission products

Isotope	Half-life	Amount ~~of~~ in 1 m.c. of mixed fission products, measured at 12 hours	Maximum permissible level in body (I.C.R.P.)
Barium 140	12.8d	5 µc	1 µc
Strontium 89	53d	1 µc	2 µc
Strontium 90	25y	0.006 µc	1 µc
Iodine 131	8.0d	4 µc	0.3 µc
All iodine isotopes		150 µc	

It will be seen that even assuming that these fission products are absorbed through the lung or gut with high efficiency, the amounts corresponding to 25 r. external gamma radiation are only of the same order as the allowable peacetime levels which can be maintained continuously by occupational workers. For the short-lived isotopes in this group the factor of safety is very large and for 25 year strontium 90 there is already a factor of safety of 170.

It is suggested, therefore, subject to approval by the appropriate medical authorities, that the retention of 1 mc. of fresh fission products in the body would be a smaller hazard than 25 r. of whole body irradiation.

Trial on 8th May 1951

15 mr/hr. of external gamma radiation corresponded to an average of 0.024 µc/m^3

Hence multiplying both sides by 1700 we have 25 r/hr. of external gamma radiation corresponding to 40 µc/m^3 activity in the air.

/Under

Under these circumstances only about 50 μc of activity would be inhaled, and about 25 μc retained temporarily, during a working period in which 25 r. of external radiation would be accumulated. The inhalation hazard in this case would be quite negligible.

3.3 Discussion and conclusions

Even without allowing for the various factors enumerated in 3.1 which would be expected to provide a further factor of safety of about 10 in most circumstances, it is seen that under the worst conditions (exemplified in the first trial) the inhalation hazard is smaller than the external radiation hazard, while under the more usual conditions exemplified in the second trial, the inhalation hazard is almost negligible.

Thus these two trials suggest that under the conditions of rescue work in fission product contaminated debris within 24 hours of an atomic explosion, the external radiation hazard will dominate and provided the exposure is kept below 25 r. of external gamma radiation, there will be no hazard due to inhaled activity. The conclusion does not apply to other sources of fission product contamination, such as deliberate dissemination by an enemy of fission product dust.

June 1951

A. C. Chamberlain
G. R. Stanbury

Part 4 Discussion of Medical Implications by Group Capt. D. A. Wilson, R.A.F.M.S., and Major A. R. T. Lundie, M.C., R.A.M.C.

The situation considered is that in which the maximum dose of external whole body gamma radiation delivered to an individual rescue worker during a shift is not permitted to exceed 25 r. and when not more than 24 hours have elapsed since the creation of a radiation hazard by an atomic explosion. Under these circumstances the controlling hazard, due to "fresh" fission products is the external radiation flux.

As the highly charged fission product particles become adsorbed on to the normal dust particles in proportion to the surface area and are firmly held there, the known behaviour of ordinary dust particles in the respiratory tract is relevant to this discussion, and may be briefly reviewed at this point.

Those particles down to 5 μ diameter will be trapped in the nasal area, and on the ciliated epithelium lining the respiratory tract. The ciliated epithelium lining the trachea, bronchi and bronchioles tends to move particles towards the oesophagus. They are subsequently ingested or expectorated. By these means dust is cleared from the lower respiratory tract in about 2-3 hours. A proportion of those under 0.5 μ will be exhaled. The remainder, with a maximum proportion in the region of 1 μ will remain trapped in the alveoli. It has been shown that such particles remain in situ for approximately 72 hours.

By the end of this shift, if no respirator is worn, the rescue worker will have a mixture of radioactive and non-radioactive dust on his clothing and exposed skin, with further deposits -

(1) coating the nostrils and lips

(2) trapped in the tonsillar crypts and post nasal lymphoid tissue

(3) in the alveoli and lung parenchyma

(4) on the surface of the respiratory tract being moved towards the pharynx. They may remain 2-3 hours in the trachea.

The particles on the clothing are removed by undressing at the end of the shift; washing removes the skin contamination and particularly the particles mentioned under (1). (2) and some of (4) may be partially removed by gargling and douching; (3) cannot be reached and therefore constitute the main radiation hazard due to inhalation.

The levels of airborne activity and distribution of particle sizes at Falfield have been discussed earlier in this report. In the situation under consideration, 15-25% of the dust inhaled would be retained for up to 72 hours, if the particle size distribution was similar to that produced at Falfield. The additional beta dose to the lung would be 10-20 r.e.p. integrated over the first 24 hours of this period. Thereafter, the remaining activity from the fresh fission products would be almost negligible. This would only be given to the lungs and bronchi.

/Hence

Hence, a rescue worker employed under the conditions described above would have received a general total body dose of 25 r. while the total integrated dose to his lungs and bronchi would be approximately equivalent to 35-45 r., a dose which is not calculated to produce any undue effect.

The total quantity of long-lived fission products which would be inhaled under these circumstances is only of the order of allowable peacetime tolerances for the few dangerous isotopes in this class.

The level of radiation encountered will not stop ciliary movement and hence will not diminish removal of dust from the trachea and bronchi. Serious contamination of the cranial sinuses can be discounted.

Under different conditions with a longer period of time since the explosion took place, or where an area has been contaminated with stored fission products, with a high proportion of long-lived isotopes, the situation will be quite different. In one such case the low gamma radiation flux of 1.3 mr/hr. was accompanied by alpha emission of 7,000 times tolerance and beta emission of 10,000 times tolerance. It is conditions such as these which postulate the retention of the respirator on the training programme.

Under the conditions originally described, i.e. where a rescue worker is employed during the first 24 hours after an atomic explosion, provided the total integrated dose of gamma radiation delivered to the whole body does not exceed 25 r, no serious additional radiation hazard will be imposed by working without respirator. The wearing of a respirator may, however, be necessary where additional or different hazards exist.

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APPENDIX I

REMARKS ON PROTECTIVE CLOTHING

by C.D.E.E. Porton

Purpose of the Clothing

A preliminary design of a new type of suit for special defence parties to protect against atomic fission products and B.W. and C.W. agents.

Description of the Clothing

Suit

A one-piece coverall garment made in a closely-woven showerproofed gaberdine fabric, open at the front only and closed by means of a double line of press fasteners.

Double storm cuffs and leggings are fitted. Adjustment of cuff and leg closures is by means of a piece of circular section elastic braid.

Hood

A simple covering for the head made in the same fabric as for the suit with a front aperture to accommodate the facepiece of the respirator. This aperture is readily adjustable by means of a piece of circular section elastic braid.

The original hood was fitted with a double skirt, the inner skirt fitting inside the suit and the outer one being worn outside the garment.

Gum boots, rubber A/G gloves and respirators were also worn.

Results of the Trial

General

If the results of the "frisking" immediately after the trials can be taken as a guide, surprisingly little dust was picked up by the clothing, except where definite pockets had formed, e.g. at the wrists and on the shoulders where the strap of the respirator haversack rucked up the skirt of the hood.

Hood

The fit on the facepiece was satisfactory and no trace of dust was found inside the hood.

The double skirt was reported to be too hot during the first test and so for the second test the inner skirt was removed.

In use this single skirt was blown up at the back over the steel helmet, allowing dust and dirt to enter around the neck

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of the wearer. This is definitely an undesirable point and even if the hood is anchored down to the back of the overall, there will be a tendency for dust to find its way under the skirt during spells of work in the crawling and prone positions. It may be necessary to provide a tighter fitting neck to the suit.

Suit

The press fastener method of closure at the cuffs and ankles was tried out in the first test but the fold over was a trap for dust. In the second test a simple draw elastic closure was used and found satisfactory.

During arduous work the sleeves worked up the arms and, in time, over the top of the gloves. This can be prevented by putting simple anchoring tapes to pass across the palms of the hands.

With the token reinforcement patches, it was found that sizing of the garment became extremely critical especially in length of leg. To overcome this the sizes of patches were increased, particularly the knee patches which were increased from 14" to 19" in length. These appeared satisfactory in the small scale tests carried out on this occasion. The outer sleeve will require lengthening by approx. $1\frac{1}{2}$".

Gloves
Boots

The rubber A/G gloves and rubber gum boots were satisfactory in use during these tests.

Both would be easy to decontaminate. The risk of punctures by protruding nails etc. is one that will have to be considered.

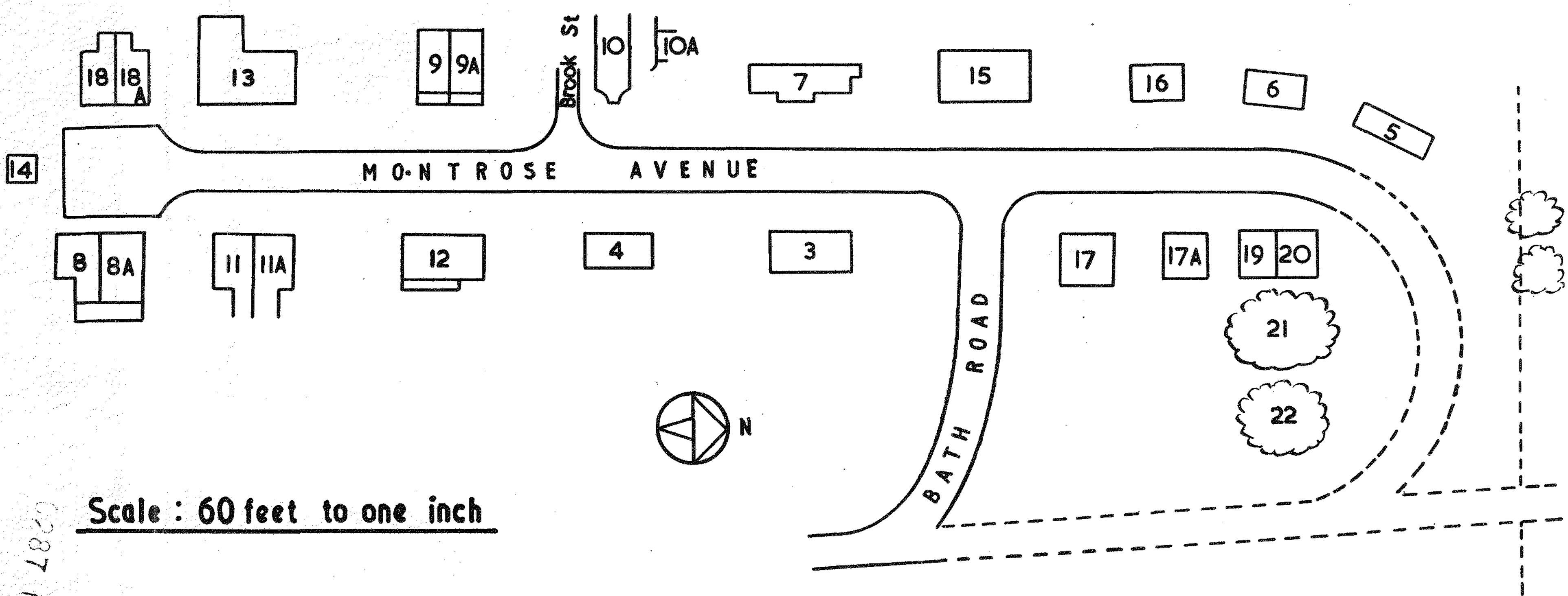
Possibly oilskin gloves with overmittens might be preferable for certain types of work.

Respirators

The use of a self-contained respirator would be an improvement for comfort and ease of movement.

PLAN OF RESCUE RANGE AT CIVIL DEFENCE SCHOOL, FALFIELD GLOS.

Fig. 1.



Scale : 60 feet to one inch

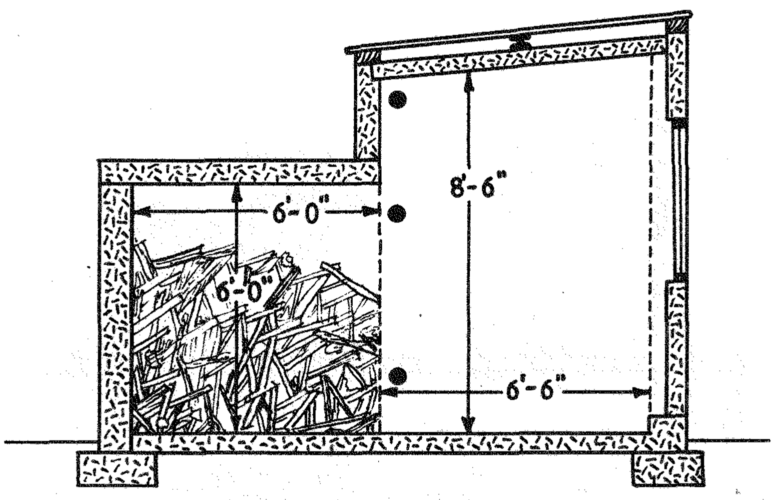
DETAILS OF CUBICLE USED FOR WORK IN CONFINED SPACE — SET No. 3.

Scale: 4 feet to 1 inch

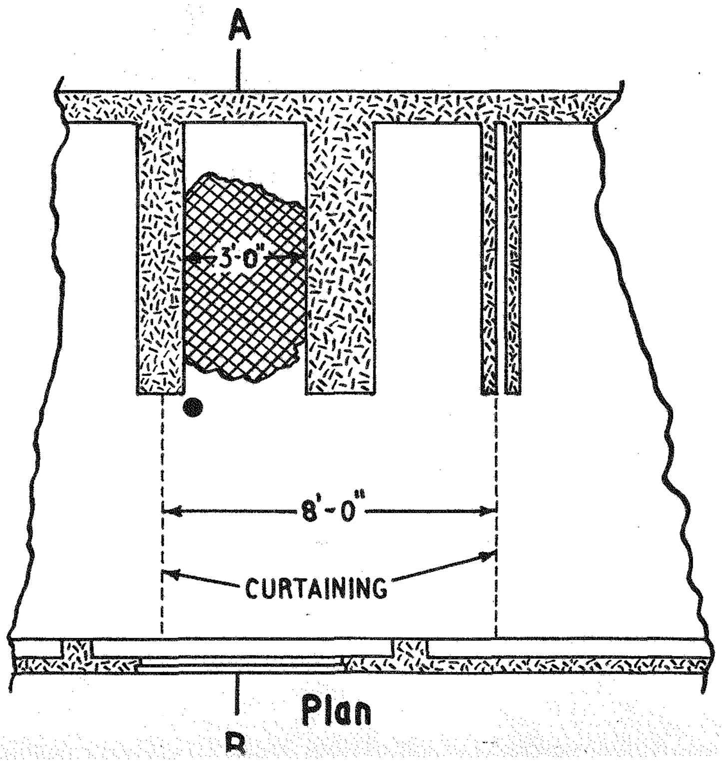
Fig. 2.

Approx. area treated with active dust shown thus:

Positions of dust samplers: ●



Section through A - B

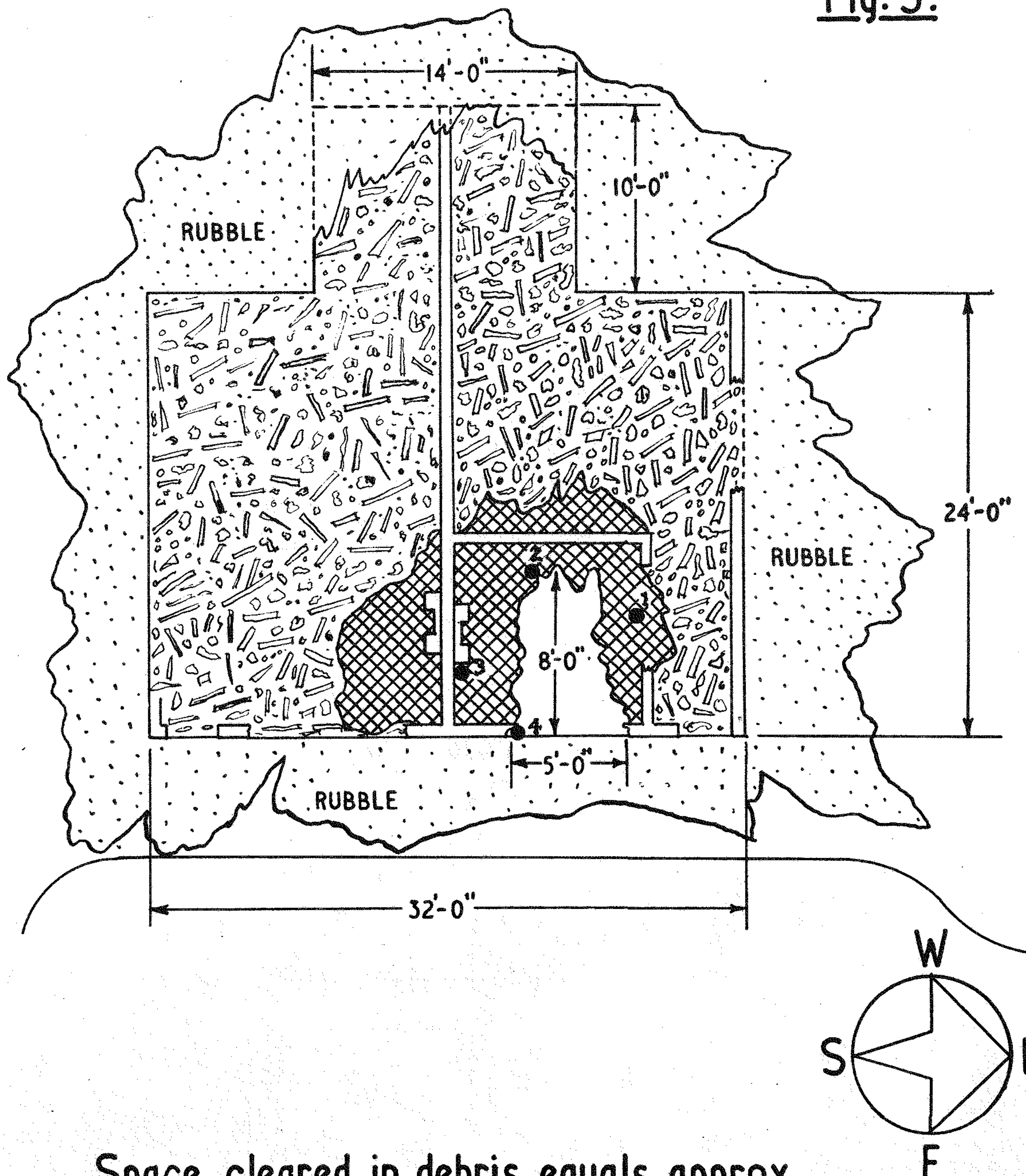


Plan

SKETCH PLAN OF SITE USED FOR DEBRIS CLEARANCE IN OPEN — SET No. 18A.

Scale: 8 feet to 1 inch

Fig. 3.



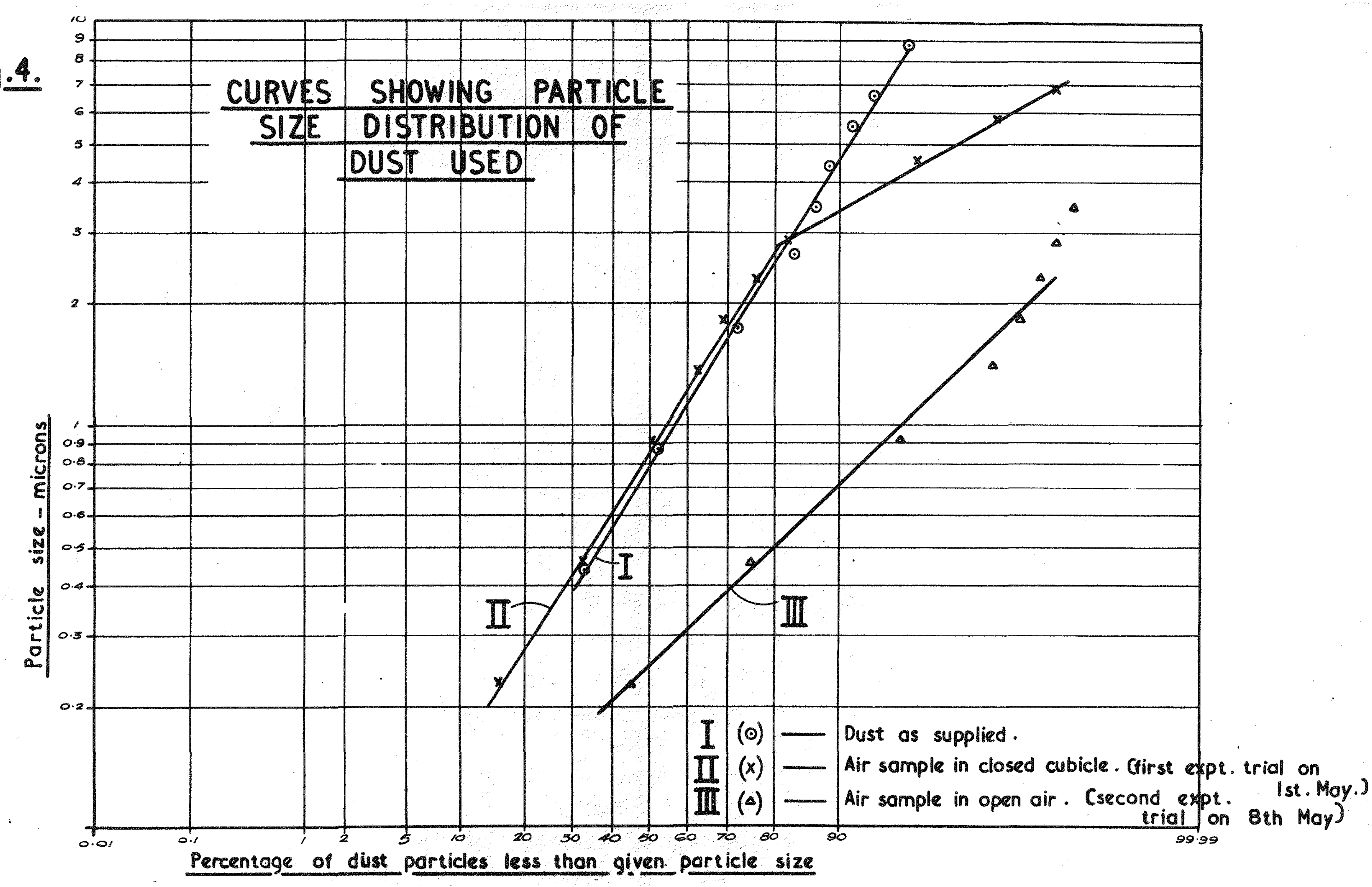
Space cleared in debris equals approx. 8'-0" x 5'-0" of front room measuring 10'-0" x 10'-0"

Approx. area of debris treated with active dust shown thus:-

Positions of dust samplers:- •

0287-020

Fig.4.



CURVES SHOWING PARTICLE SIZE DISTRIBUTION OF DUST USED
Particle size - microns
Percentage of dust particles less than given particle size
I
II
III
I (⊙) — Dust as supplied.
II (x) — Air sample in closed cubicle. (first expt. trial on 1st. May.)
III (△) — Air sample in open air. (second expt. trial on 8th May)
10
9
8
7
6
5
4
3
2
1
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·01
0·1
1
2
5
10
20
30
40
50
60
70
80
90
99·99

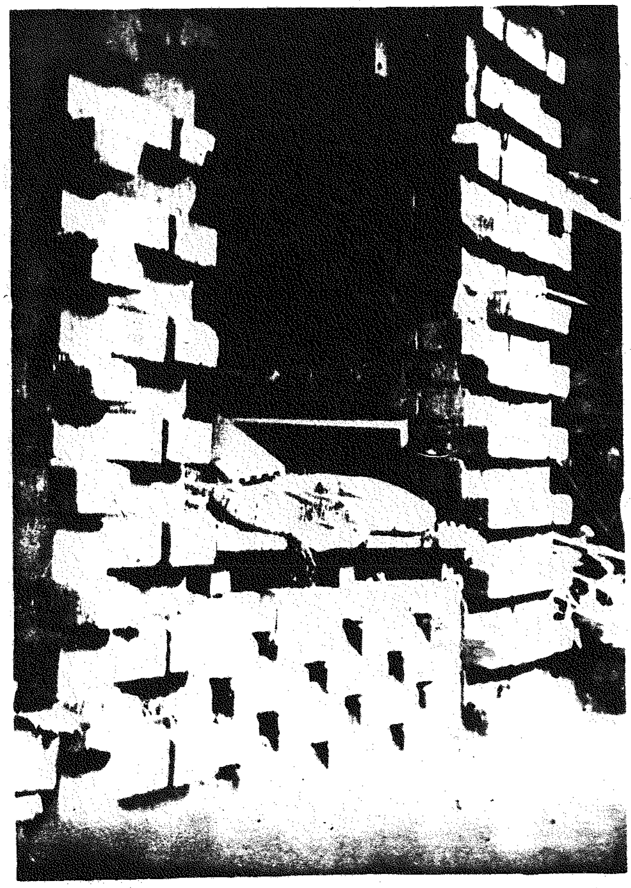


Plate 1 : Cubicle used for first trial

Plate [illegible] : [illegible] (... sampling filter [illegible] on window frame in middle of picture)

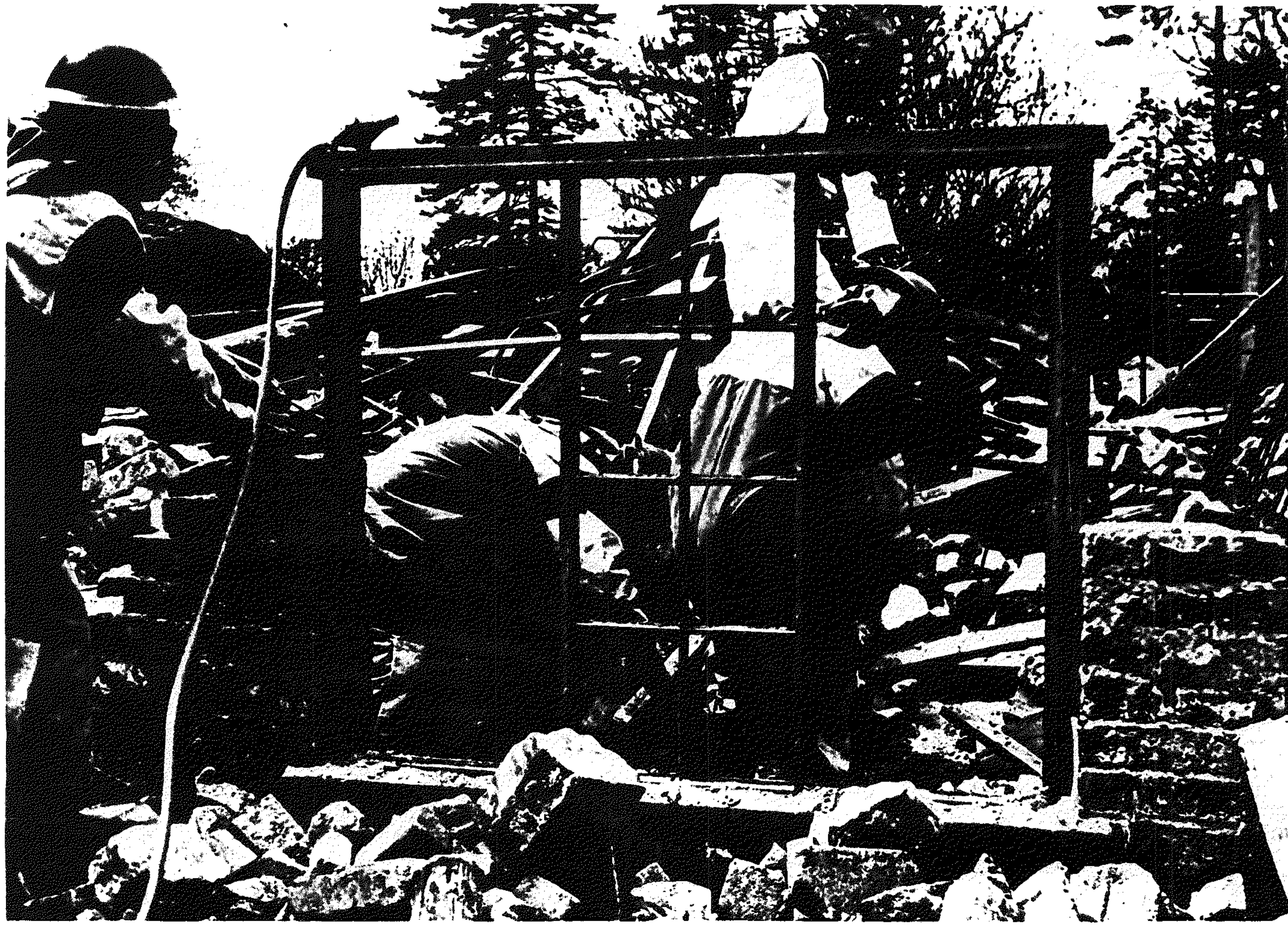


Plate 3 : Second trial, close-up view showing protective clothing, and radiation meter type 1118 in background